SEARCH FOR THE DIRAC MONOPOLE BY MEANS OF VAVILOV-CHERENKOV RADIATION AT THE 70 GeV IHEP (INSTITUTE FOR HIGH ENERGY PHYSICS SERPUKHOV) PROTON SYNCHROTRON

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At the proton energy of 70 GeV on the internal target of the IHEP proton synchrotron the search was made for magnetic charges over the Vavilov-Cherenkov radiation and characteristic polarization. Eight Cherenkov counters of a special construction served as detectors. Possible events were recorded with two fast five-ray oscillographs triggered by 6-fold coincidences. The efficiency of the magnetic charge recording was about 10%.

The proton beam of $6{\cdot}4 \times 10^{14}$ intensity traversed the target-radiator; and not a single case of the production of the Dirac monopole with the magnetic charge from minimal one of about $2/3g_D$ ($g_D = 68{\cdot}5e$) up to $2g_D$ was recorded. This means that in the conditions of our experiment the upper boundary of the cross section of the Dirac monopole production by 70 GeV protons per nucleon of Si and O nuclei for magnetic charges of masses from 3 up to $5{\cdot}5m_p$ was found to be $\sigma(95\%) \lesssim 10^{-40}$ cm^2.

I. INTRODUCTION

Dirac [1, 2] has been the first to indicate that a magnetic charge may exist in Nature and has predicted its properties: anomalously large value,

$$g_D = \left(\frac{e^2}{\hbar c}\right)^{-1} \cdot e \cdot \frac{n}{2} \quad \left(g_D = 3{\cdot}29 \times 10^{-8}\,\mathrm{Oe}\,.\,\mathrm{cm}^2\right),$$

as well as the multiplicity compared to the elementary electric charge.

Numerous negative results of the search for hypothetic magnetic charges [3—7] and the nontrivial reasons of the failures of their discovery [8—10] as well as the importance of fundamental theoretical predictions of the role of magnetic charges in matter structure [11—15] urge the experimentalists to search for magnetic charges by means of various techniques.

The basic idea of the present experiment and its preliminary results have been described in [16]. Detailed description of the experimental technique and the final results are given here.

2. METHOD FOR SEARCHING FOR MAGNETIC CHARGES BY USING VAVILOV-CHERENKOV RADIATION

The 70 GeV incident protons may produce in the $\mathrm{p} + \mathrm{N} \to \mathrm{p}' + \mathrm{N}' + \mathrm{g} + \tilde{\mathrm{g}}$ reaction the monopole–antimonopole pairs $(\mathrm{g}, \tilde{\mathrm{g}})$ whose each component will have

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velocities exceeding the threshold of arising Vavilov-Cherenkov radiation in the medium having the refractive index $n = 1{\cdot}5$. Fig. 1 shows the statistical impulse spectrum of monopoles with masses $m_g = 4m_p$, emitted in the lab. system at 5° calculated without taking into account the interactions between g and $\tilde{\mathrm{g}}$. As is seen from the figure, the average impulse p_g (5°) = 22 GeV/c, and the spectrum minimal impulse

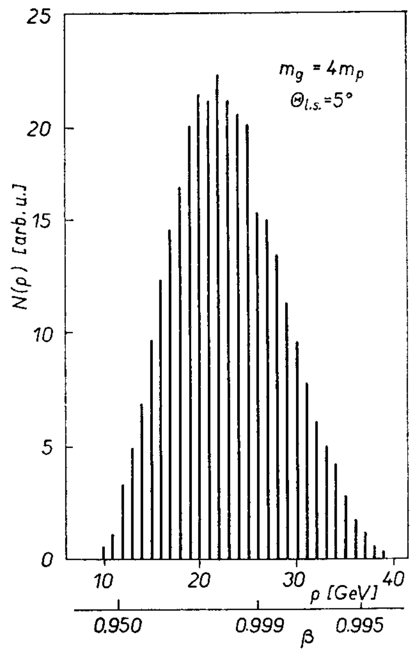


Fig. 1. Statistical impulse spectrum of magnetic charges arising in the $p + N \to p' + N' + g + \tilde{g}$ reaction with 70 GeV protons calculated by the Monte-Carlo method with the monopole mass $m_g = 4m_p$ emitted in the lab. system at 5°.

$p_{\min} \cong 10$ GeV/c. For the monopoles with masses from $m_g = 2m_p$ to the limit mass in our experiment $m_g = 5{\cdot}5m_p$, all the magnetic charges will have velocities $\beta > 0{\cdot}9$, which considerably exceeds the threshold of appearance of Vavilov-Cherenkov radiation for quartz ($\beta_{\text{thr}} = 0{\cdot}68$).

The energy of Vavilov-Cherenkov radiation from the magnetic charge (g) moving at the velocity β at a unit length of its path is determined according to Frank [17] by the formula

$$\frac{\mathrm{d}W^g}{\mathrm{d}l} = \frac{n^2(\omega)\, g^2}{c^2} \int_{n(\omega)\beta > 1} \left(1 - \frac{1}{n^2(\omega)\, \beta^2}\right) \omega \, \mathrm{d}\omega \tag{1}$$

where $n(\omega)$ is the refractive index of the medium, ω is the angular frequency of radiation.

The ratio of radiation energy to the magnetic charge (g) and the electric (e) with their equal velocities β is determined by the equality $W^g/W^e = n^2(\omega)\, g^2/e^2$. For the Dirac monopole with the charge $g = 68{\cdot}5e$, moving in medium with $n(\omega) = 1{\cdot}5$, $W^g \cong 10^4 W^e$.

As has been noticed by FRANK [18], the polarization of Vavilov-Cherenkov radiation from the magnetic and electric charges differ by the rotation of the electric vector by 90°.

A powerful flash of Vavilov-Cherenkov radiation having peculiar polarization expected from the magnetic charge simplifies the search for magnetic charges on the background radiation from the electrically charged particles. One may mention here as one of the peculiarities of our experimental procedure the fact that a Vavilov-Cherenkov radiator and the target were superimposed. This allowed in principle to detect Dirac monopoles at the moment of their production, i.e. to detect both stable magnetic charges and unstable ones having the lifetimes $\tau_g \lesssim 3 \times 10^{-11}$ sec.

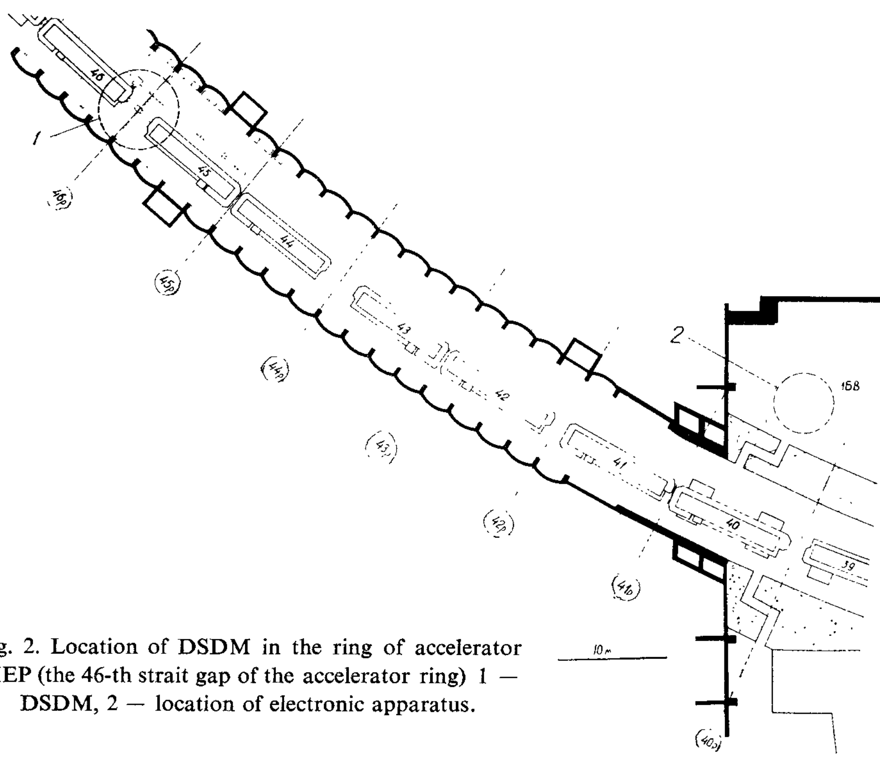


Fig. 2. Location of DSDM in the ring of accelerator IHEP (the 46-th strait gap of the accelerator ring) 1 — DSDM, 2 — location of electronic apparatus.

3. SHORT DESCRIPTION OF THE DEVICE FOR SEARCHING FOR THE DIRAC MONOPOLE (DSDM)

The device aimed at searching the Dirac monopole was located in the 46-th straight gap of the 70 GeV proton synchrotron IHEP (Serpukhov) (Fig. 2). The general view of DSDM is shown in Fig. 3 (view against the proton beam). The basic parts of DSDM are the following: a vacuum chamber serving simultaneously as a vacuum section of the accelerator ring and eight identical optical devices (which may be called conditionally as Cherenkov counters) placed along the azimuthal angle ϕ at each 18° outside the accelerator ring as is shown in Fig. 3. A target radiator of special form (Fig. 4) was inserted into the vacuum chamber through a special sluice simultaneously

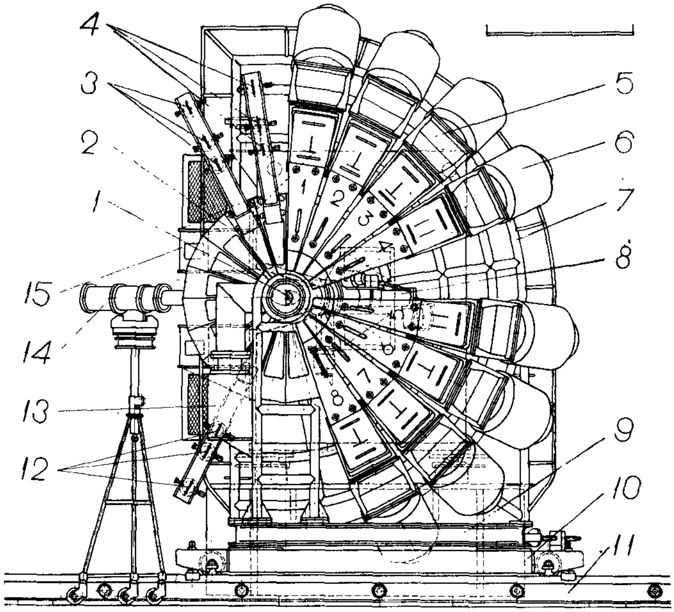
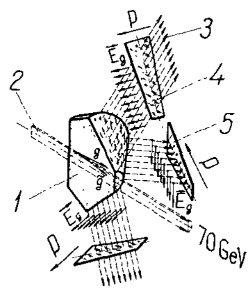


Fig. 3. General view of the device for searching for the Dirac monopole by means of Vavilov-Cherenkov radiation (view against the 70 GeV proton beam). 1 — target-radiator, 2 — vacuum chamber, 3, 4, 12 — monitor counters for control of proton intensity and "feedback" counter, 5 — Cherenkov counter (total of eight pieces), 6 — lead shielding, 7 — truss-support, 8 — mechanism for target introducing, 9 — adjusting-turning plate, 10 — base-plate, 11 — rails, 12 — the additional titanium pump, 14 — television camera PTU-101, 15 — 45-th magnet of ring of the IHEP proton synchrotron.

Fig. 4. Target-radiator and the scheme for analysing by means of polaroids. 1 — quartz target, 2 — 70 GeV proton beam, 3 — direction of Vavilov-Cherenkov radiation from the magnetic charge, 4 — $\perp$-polaroid, 5 — $\|$-polaroid.



with the acceleration cycle. The chamber had 8 transparent trapezoidal windows of plexiglass 15 mm thick for emitting radiation from a target-radiator. Each of the eight windows had an adjacent Cherenkov counter. Its design is shown in Fig. 5.

The fraction of cone of Vavilov-Cherenkov radiation arising in the target (1) and hitting each Cherenkov counter (1–8) was $\Delta\phi = \pm 3{\cdot}5°$ along the azimuthal angle. The radiation was focused with a lens (3) with $f = 150$ cm on the input of each counter and was analyzed with polaroids (4). After being reflected by a set of plane

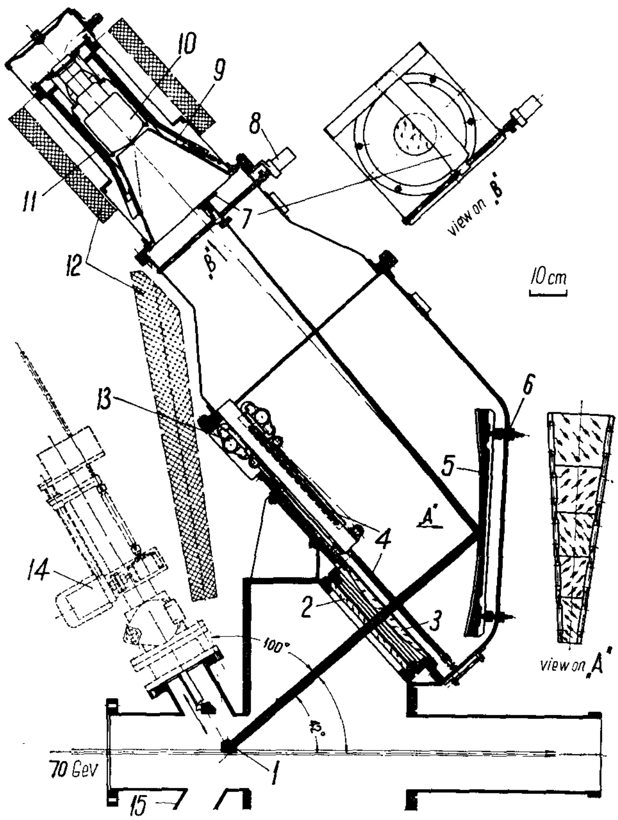


Fig. 5. Schematic view of the Cherenkov counter. 1 — target-radiator, 2 — outlet window of the vacuum chamber, 3 — focusing lens, 4 — polaroids (|| and ⊥), 5 — set of plane mirrors, 6 — control screw, 7, 8 — remote-controlled screen, 9 — cone mirror, 10 — 58 AVP photomultiplier, 11 — photomultiplier magnetic shielding, 12 — lead shielding, 13 — mechanism of polaroid motion, 14 — mechanism for target introducity.

mirrors (5) sprayed with aluminium and placed with respect to each other at an angle of 3°49′ the radiation was collected on the photocathodes of photomultipliers (10) of 58 AVP type on the working diameter of 100 mm by means of conic mirrors (9). A movable remote controlled opaque screen (7, 8) 65 mm wide was inserted in the focal plane of the counter lense in order to absorb Vavilov-Cherenkov radiation arising in the target from the primary 70 GeV proton beam.

The set of plane mirrors (5) was put in the calculated position by means of a special optical device and control screws (6). In the working conditions the polaroids in counters 1, 2, 3 and 6, 7, 8 were in the position for transmitting radiation from magnetic charges ($\perp$ – polaroids), while in counters 4 and 5 the polaroids transmitted radiation coming from charged particles ($\parallel$ – polaroids).

The photocathodes of photomultipliers with respect to the target centre were placed at 165 cm at an angle of $\vartheta = 100°$ to the direction of the proton beam for reducing the background of charged particles passing the target mainly forward. The photocathodes were screened from the direct impact of particle from the target by pyramidal lead blocks (12) 70 cm thick each.

The target radiator (1) was made of radiation-resistant fused quartz of "Herasil-1" type. It had the shape of one half of the frustum of a cone with a vertex angle of $2\alpha = 96°$ and 40 mm thick in the beam direction. The proton beam was guided to the target via the centre of the plane face (Fig. 4).

The primary proton beam was monitored with two telescopes M_1 and M_2 (3 and 12 in Fig. 3) consisting of three scintillation counters each. The counter crystals were $5{\cdot}0 \times 0{\cdot}8 \times 0{\cdot}8\ \text{cm}^3$. The absolute fit of the relative monitor readings to the proton beam intensity in the accelerator ring was performed by the Serpukhov synchrotron staff by measuring current with pickup electrodes. The multiple fit of monitor readings at various intensities in the ring has shown that the deviations were not larger than $\pm 15\%$.

4. EXPERIMENTAL CONDITIONS

The mean range of monopoles in quartz ($\varrho = 2{\cdot}25\ \text{g/cm}^3$) for the impulse spectrum shown in Fig. 1 is about 1·3 cm. At this range the monopole having a charge of $g = 68{\cdot}5e$ in the wavelength region corresponding to the sensitivity of a photocathode having a normal input window (from $\lambda_1 = 3000$ Å to $\lambda_2 = 6500$ Å) would emit about $2{\cdot}6 \times 10^6$ photons. If all these photons hit the same photocathode, they would knock out about 2×10^5 photoelectrons. A considerably smaller portion of radiation hits a separate Cherenkov counter viewing only a part of the radiation cone within $\Delta\phi = 7°$.

In order to determine the efficiency of the DSDM to the detection of magnetic charges at various levels of discriminating the amplitudes of pulses coming from photomultipliers by the Monte-Carlo method the number of photons of Vavilov-Cherenkov radiation hitting each of 6 Cherenkov counters [1 – 3, 6 – 8] was calculated by taking into account the kinematics of the $p + N \rightarrow p' + N' + g + \tilde{g}$ process; the intranuclear motion of nucleons in target nuclei made of SiO_2 with a limiting Fermi momentum 0·22 GeV/c; the profile of the 70 GeV proton beam guided to the target; radiation absorption in outlet windows of the vacuum chamber and lenses (with taking into account their darkening under the effect of radiation), the reflection of flat and cone mirrors, the design peculiarities of the device, the radiator shape, proton knock out from the beam due to nuclear absorption, monopole slowing down as well as the spectral and absolute sensitivities of 58 AVP photomultipliers.

Table 1

Monopole mass	η-efficiency of DSDM with $N \geqq 250$ ph.el.			η-efficiency of DSDM with $N \geqq 400$ ph.el.	
m_p	$1/2g_D$	$1g_D$	$2g_D$	$1g_D$	$2g_D$
3·0	—	0·19 ± 0·07*)	—	0·064 ± 0·043	—
4·0	—	0·20 ± 0·07	—	0·083 ± 0·045	—
5·0	0·04 ± 0·03	0·25 ± 0·07	0·19 ± 0·07	0·133 ± 0·056	0·164 ± 0·064
5·5	—	0·25 ± 0·07	—	0·154 ± 0·061	—

*) Statistical errors of the 3σ confidence calculations are given.

It is worth noting that in the calculation of monopole moderation only ionization losses were taken into account. Monopole energy losses for bremsstrahlung radiation were neglected. This is due to the fact that the radiation length X_g for magnetic charges from g_D to $2g_D$ exceeds their mean range in the radiator-target.

The results of calculation are shown in Table 1 for discrimination threshold corresponding to $N_{\text{phel}} \geqq 250$ and $N_{\text{phel}} \geqq 400$ photoelectrons, magnetic charge masses m_g equal to 3, 4, 5 and $5{\cdot}5 m_p$ as well as for various magnetic charges in the units of the minimal Dirac $g_D = 68{\cdot}5$ e.

A possibility to separate the magnetic charges at the considerable background of charged particles based on the following estimates. With the maximum proton intensity inside the accelerator ring in 2×10^{12} protons and their uniform stretching per 1 sec for the resolution time of six fold coincidences $\tau = 10$ nsec a number of 2×10^4 protons passes through the target-radiator.

All charged particles passing at an angle not larger than $\vartheta < 10°$ to the direction of the primary beam have velocities β exceeding the emission threshold of Vavilov-Cherenkov radiation and are the sources of background Vavilov-Cherenkov radiation in a quartz radiator-target.

The particles may be the following: 1) the protons of the 70 GeV primary beam, 2) secondary nuclear particles, mainly, pions, kaons, protons, 3) electrons and positrons arising from gamma-quanta related to the decay of neutral pions generated in the target, 4) delta electrons knocked out by the primary protons by secondary charged particles as well as by the monopole itself.

The contribution of these particles to background radiation is presented in Table 2.

If one neglects the protons of the primary beam whose radiation is absorbed by the screen, then for the average number of background one-charge particles arising simultaneously in a quartz radiator one obtains the evaluation of $1{\cdot}1 \times 10^4$. These particles produce the same radiation as the monopole with $g = 68{\cdot}5e$. But it will be attenuated by a polaroid about 100 times (the polarizing power of the polaroids used

Table 2

Background radiation from particles	Number of one-charged particles	Number of delta-electrons
70 GeV protons of the primary beam	$\approx 2 \times 10^4$	$\approx 2{\cdot}4 \times 10^2$
Secondary nuclear particles (mesons, protons, kaons)	$\approx 6{\cdot}4 \times 10^3$	$\approx 1{\cdot}1 \times 10^2$
Electron–positron pairs from π^0-mesons	$\approx 4 \times 10^3$	—
Monopole with $g = 68{\cdot}5e$	—	$\approx 10^2$

in the experiment was 99·0–98·5% in the wave-length range from 3500 to 7000 Å according to the factory passport). However, the following three facts must be taken into account: 1) secondary (background) charged particles may have ranges in the radiator about two times larger than the mean range of the magnetic charge $g = 68{\cdot}5e$, 2) the K-multiplicity of proton passage through the target-radiator increases the contribution to background radiation from delta-electrons K times, 3) a monopole-antimonopole pair having approximately similar ranges are produced in a single collision event. Thus, the amplitude of the background signal A_{bagd} with with respect to the signal from the monopole is $A_{\text{bagd}}/A_g \sim 1{\cdot}2 \times 10^{-2}$.

5. BLOCK DIAGRAM OF THE ELECTRONICS

Pulses from photomultiplier anodes of Cherenkov counters 1, 2, 3, 6, 7, 8 (Fig. 6) via the discriminators $d_1 - d_8$ and the delay lines $DL_1 - DL_8$ were fed to triple coincidence circuits CC_1 and CC_2 with the resolving time $\tau = 5$ nsec. From these circuits the coincidence pulses were fed to the double coincidence circuit CC_3 with $\tau = 10$ nsec. The pulses of six-fold coincidences triggered the sweeps of two five-ray oscilloscopes which detected the pulses entering from the last dynodes of eight photomultipliers 58 AVP amplified preliminary with wide-band amplifiers U3-11.

An event of the Dirac monopole production should be accompanied by the appearance of large pulses ($N \geqq 250$ ph.el.) simultaneously in counters 1, 2, 3, 6, 7, 8 and their absence in counters 4 and 5.

The intensity of protons hitting the target was controlled with two monitors, M_1 and M_2.

The DSDM operated simultaneously with the accelerator cycle of about 8 sec duration. After about 1 sec on 100 MeV proton injection to the accelerator ring by means of the DSDM control panel a starting pulse was sent to the input circuit of the target-radiator, which approached the centre of the vacuum chamber, as protons were accelerated in 30 bunches of about 25 nsec duration and the proton beam compression to a cord of 7 – 10 mm in diameter. Before 200 – 300 msec the end of the acceleration cycle the plane face of the target came to a working position (+5), i.e. it did not reach

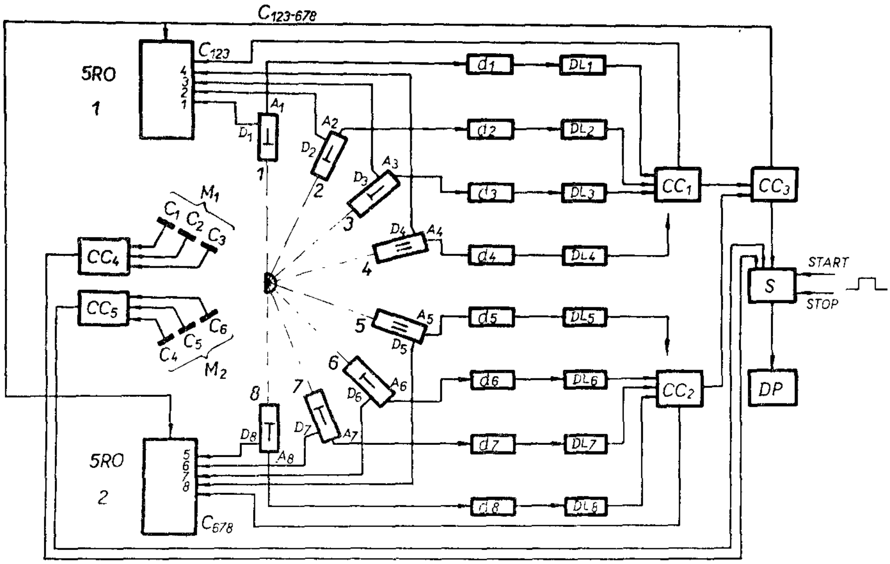


Fig. 6. $A_1D_1 \div A_8D_8$ — anodes, last dynodes of the photomultiplier, $d_1 \div d_8$ — discriminators, $DL_1 \div DL_8$ — delay lines, $CC_1 \div CC_8$ — coincidence circuits ($\tau = 5$ nsec and $\tau = 10$ nsec), 5 RO — (1 and 2) — 5-ray oscilloscope, S — scalers, DP — digital printer, M_1 and M_2 — monitors, C_{123}, C_{678}, C_{123678} — trigger pulses from coincidence circuits.

5 mm to the centre of chamber outside the ring. On switching off radio frequency the internal beam was de-bunched and by means of a special "bump" in the "table" mode of the accelerator operation uniformly during (1 – 1·4) sec was guided to the target-radiator. The uniformity of guiding was achieved with a special "feedback" triggered from a single scintillation counter including a photomultiplier FEU-29.

The electronic circuit was triggered with a time gate opened 200 – 300 msec after the beginning of the "table" mode. The duration of the time gate was determined by the quality of the stretching uniformity and was from 0·5 to 1 sec. All the information after each cycle of the accelerator operation and the 70 GeV proton beam guided to the target was fixed from a five-ray oscilloscopes with RFK-5 photo-cameras, while the information from the counters was fixed with a set of scalers having the output on CPM-1 printer.

The amplitudes of pulses from 58 AVP photomultipliers in the number of photoelectrons were calibrated by means of the standard technique with respect to the width of amplitude distribution to its amplitude at the maximum measured by means of the NTA-512 analyzer and pulsed light sources. The accuracy of such calibration of photomultiplier amplitudes is $\pm 20\%$ according to our evaluations.

6. THE CHOICE OF OPTIMUM OPERATION CONDITIONS

The delay lines $DL_1 - DL_8$ for obtaining six-fold coincidences at any pair combination of counters $1-8$ were selected both by means of the "Cossor" pulse generator having the double pulse output and when the accelerator operated in the mode of "bunches" having about 25 nsec duration. Both the methods gave coinciding results within some nsec.

The 58 AVP photomultipliers operated at the voltage of ~ 2 kV, the last dynodes being power supplied. The voltage over all the counters (1, 2, 3, 4, 5, 6, 7, 8) was constantly controlled. The screen shielding Vavilov-Cherenkov radiation from the 70 GeV primary proton beam in the focal plane of each Cherenkov counter was put forward at the minimum counting of triple coincidences of counters 1, 2, 3 and 6, 7, 8. In order to eliminate the possibility of a photon hitting and escaping the screen, the plane face of target turned to the beam was blackened for cancelling the reflected radiation.

The fine structure of the internal proton beam due to proton "quasi-bunching" in the stretching mode of the accelerator was the basic obstacle for the normal operation of the DSDM. The duration of the "quasi-bunches" was $\tau_{qb} \cong 180$ nsec, the frequency being $f \cong 2{\cdot}6$ MHz. After putting into operation the system for suppressing "quasi-bunching" at the Serpukhov accelerator about $7{\cdot}7 \times 10^{15}$ protons were passed through the DSDM target-radiator and 120 six-fold coincidences were detected at the discrimination threshold $N \geqq$ ph.el. It turned out that for 96 events the ratio of mean pulse amplitudes recorded by the oscilloscopes, $\bar{A}_{\perp}/\bar{A}_{\parallel} \sim 1/3$, where $\bar{A}_{\perp}$ and $\bar{A}_{\parallel}$ are average amplitudes of pulses from Cherenkov counters with $\perp$ and $\parallel$ polaroids, respectively. These coincidences could not be regarded as monopoles, since for them $\bar{A}_{\perp} > \bar{A}_{\parallel}$ in any case. First, we treated them as coincidences from secondary particle radiation with the polarization $p \sim 50\%$. However, the background experiments with the cross polaroids $(\perp + \parallel)$ in counters 1, 2, 3 and 6, 7, 8 and parallel in 4 and 5 counters and the quartz target have shown that in this case there are also six-fold coincidences. The ratio of average pulse amplitudes in any of the counters with the crossed polaroids to the average pulse amplitudes in counters 4 and 5 (with parallel polaroids) $\bar{A}_{\parallel+\perp}/\bar{A}_{\parallel} \sim 1/3$, has been obtained the same as in the case of the exposure for the "expecting monopole".

In the experiment carried out with the carbon target with polaroid orientation similar to what when "expecting the monopole" one could also observe coincidences, while average amplitude of pulses on oscillograms coincided with the average amplitudes of the background run (with an SiO_2 target) in counters 1, 2, 3, 6, 7, 8.

The background runs permitted the interpretation of all 96 coincidences as those due to photoelectrons knocked out from photomultiplier cathodes with secondary particles which are the result of the "fine structure" of the internal proton beam.

This made it possible to establish a strict criterium of "monopole" when analysing six-fold coincidences. In counters 1, 2, 3, 6, 7 and 8 the pulse amplitudes must be larger than 250 ph.el., while in counters 4 and 5 pulses must be absent. Not a single event of six-fold coincidences did not satisfy this criterion. The probability of superimposing the "monopole" event and the "fine structure" event has been found to be about 10^{-10}. The remaining 24 events occurring the "expectation" mode were interpreted as "a discharge on the accelerator chamber walls" since the oscillograms were analogous to those obtained by the additional background run with a removed target-radiator. In these cases a considerable number of about similar pulses having the amplitudes $N \geqq 250$ ph.el. were detected on all the oscillograms from counters 1, 2, 3, 6, 7 and 8 and 4 and 5. Besides, the shape of these oscillograms did not differ from those of oscillograms having 6-fold coincidences when operating with a carbon target.

The loads of all Cherenkov counters with the chosen thresholds of the discriminators $d_1 - d_8$ did not exceed 10^6, while the photomultipliers operated in the linear mode according to the sum of slowly and quickly changing current components.

7. CORRECTIONS AND THE RESULTS OF THE EXPERIMENTS

Since the experiment was performed in heavy radiation conditions, it was necessary to calibrate pulse amplitudes from the photomultipliers before each run. Calibration made after the last run of the DSDM operation showed that the maximum fall of the absolute sensitivity of the photocathode of 58 AVP photomultipliers was about 30%.

Besides, six target radiators made of various radiation-resistant quartz samples were used in the experiment. They changed their colour to various degrees under the effect of 70 GeV proton irradiation.

This fact has shown that the pulse amplitude due to radiation absorption in the target-radiator was reduced by 28%.

The resulting reduction of the pulse amplitude due these two factors was 58%. Thus, the real threshold corresponded to $N \geqq 400$ ph.el. while the device efficiency was reduced to values presented in Table 1.

Taking into consideration the total proton flux in $7{\cdot}7 \times 10^{15}$ protons passed through the target-radiator, the effective thickness of the target l_{ef}, η the device efficiency to the detection of Vavilov-Cherenkov radiation from the monopole-antimonopole pairs, with given discrimination threshold of pulse amplitudes, the multiplicity K of passing 70 GeV proton through the target-radiator the upper limit has been found for the monopole production cross section by 70 GeV protons per nucleon of target nuclei in the reaction $p + N \rightarrow p' + N' + g + \tilde{g}$ according to the formula

$$\sigma(95\%) < \frac{3}{I_p N_n \eta K} \tag{2}$$

where N_n is the number of nucleons per cm^2 of the target with $l_{\text{ef}} = 3$ cm. The multiplicity of passing of 70 GeV protons through the DSDM target was calculated by using formulas given in Ref. [3], the peculiarities of the Serpukhov proton synchrotron [19] being taken into consideration $K_{\text{calc}} = 8{\cdot}4$. The quantity K was also determined experimentally by irradiating the thin (20 micron) carbon-containing film placed along the edge of the target-radiator from the direction of the proton inlet to the target and the application of the

$$^{12}_{6}\mathrm{C}(\mathrm{p}, \mathrm{pn})\, ^{11}_{6}\mathrm{C} \xrightarrow{\beta^+} {}^{11}_{6}\mathrm{B}$$

reaction. The cross section of this reaction at 70 GeV obtained by rough extrapolation of data taken from Ref. [20] at the proton energy of 28 GeV was taken to be 30 mbarn. The experimental value has been found equal to $K_{\text{exp}} = 8{\cdot}3$ which agrees with the calculational value.

With $I_p = 7{\cdot}7 \times 10^{15}$, $N_n = 4{\cdot}07 \times 10^{24}$, $K = 8{\cdot}3$ and the DSDM efficiency for detecting the monopoles of various masses given in Table 1, the cross section upper limit averaged over the range of monopole masses from $m_g = 3m_p$ to $m_g = 5{\cdot}5m_p$ according to the formula (2) has been found equal to $\sigma(95\%) \gtrsim 10^{-40}$ cm^2. These data refer to the region of magnetic charges from $2/3g_D$ to about $\sim 2g_D$ with the lifetime $\tau_g \gtrsim 3 \times 10^{-11}$ sec.

The negative results of searching for magnetic charges in all the experiments including those at 70 GeV and 300 GeV [7], may be explained from the point of view of the prohibiting principle for the existence in Nature of free magnetic charges, proposed by Kursunogly [21] on the basis of consequences obtained from the generalized gravitation theory. A further development of this theory and experiments on accelerators with still higher energy permit to ascertain that this prohibition is absolute.

The authors express their deep gratitude to the management of the Laboratory of Nuclear Problems for overall support and constant assistance in this work and especially to the corresponding member of the Academy of Sciences, Prof. V. P. Dzhelepov, Prof. A. A. Tyapkin and Prof. L. I. Lapidus, to the board of directors of JINR and IHEP for the possibility of carrying out this work, to all IHEP staff who provided reliable operation of the accelerator and proton beam and especially to the corresponding member A. A. Naumov, Yu. M. Ado, A. A. Zhuravlev, V. G. Rogozinsky, O. D. Pronin, M. N. Bulgakov, V. I. Zaitsev, A. G. Nevsky, V. L. Bruk, Yu. N. Orlov, K. P. Myznikov, V. P. Gridasov, B. A. Zelenov, A. Vasyukhin and also E. F. Sokolov and V. E. Borodin.

We are grateful to V. M. Sidorov, Yu. A. Batusov and V. P. Perelygin for discussions of the primary proposal of this experiment, to Yu. K. Akimov (a co-author of the proposal) and A. F. Dunaitsev for assistance and valuable advices, to P. Šulek (a co-author of the proposal) for calculation of the apparatus SDM efficiency, to V. G. Zinov, A. N. Sinaiev and Yu. G. Budya-

SHOV for providing the experiment with standard electronics, A. T. VASILENKO, Prof. M. I. SOLOVIEV, YU. G. BASHA for continuous help and to YU. N. EFIMOV, V. V. ERMAKOV, P. LUPTAK, V. N. SOSHNIKOV, T. I. KOZLOVA and L. I. VARGANOVA for their large work in overall ensuring of this experiment.

The authors express their gratitude to the workers of the enterprise Dioptra (Turnov, ČSSR) for making of optical details for the device for SDM.

Received 27. 1. 1976.

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